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BORDEN'S REVIEW *of* NUTRITION RESEARCH

TRACE ELEMENTS IN NUTRITION

III. IRON

BORDEN'S REVIEW
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TRACE ELEMENTS IN NUTRITION

III. IRON

The amount of iron present in the body of man is small, not more than a few grams. Yet this amount is vitally important to a number of living processes involving cellular respiration and oxidation. Inasmuch as iron is an element, it cannot be synthesized by the animal body but, like most of the vitamins, must be supplied from external sources such as food. It is utilized largely in the formation of the red blood cell pigment, hemoglobin. Unlike the vitamins, however, iron is not destroyed or used up in the body, but is very efficiently conserved and, except for small amounts which may be excreted, is utilized over and over again. For this reason, anemia due to dietary insufficiency of iron does not readily occur unless associated with growth, pregnancy, blood loss or other conditions producing a need for iron above and beyond normal requirements.

Historical Background:

The therapeutic use of iron has been recorded among the very earliest writings of western medicine. The use of this mineral antedates even these early writings and it has been said that in Greece treatment of anemia consisted in drinking water in which a sword had been allowed to rust (1). No scientific reason prevailed, prior to the eighteenth century, for the therapeutic use of iron, yet some almost uncanny human wisdom succeeded in discovering its value many centuries earlier. The reason behind the early use of iron is not clear – it may have been because iron and steel were synonymous with strength and power in battle (indeed, in older pharmacopoeias iron is referred to as mars) (2).

Among the earliest known writings on the therapeutic use of iron are those of Suydenham (3) in 1661 and Willis (4), twenty years later, who reported the successful response of chlorosis* to treatment with iron. With the discovery by Menghini (5) in 1746 of the presence of iron in human blood, a scientific explanation for the use of iron became possible. In 1832, Blaud (6) announced the formula and dosage of an iron preparation which is still in use today for the treatment of iron deficiency anemia. The development during the

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*Chlorosis, popularly known as "green sickness" because of the characteristic greenish pallor of the skin accompanying the disease, is a form of iron-deficiency anemia occurring almost exclusively in adolescent girls. The disease was particularly prevalent during the Victorian era, and it is believed that the restrictive influences of that time may have contributed significantly to its etiology.

nineteenth century of methods of counting the red blood cells an determining their hemoglobin concentrations marked a further ste in the understanding of iron deficiency.

The exact significance of the role of iron in human physiolog and nutrition has emerged only recently. The history of iron therap has been clouded by superstition, erroneous theories and by the in credible confusion existing in the classification of the anemias.

> The term, anemia, covers a wide variety of disorders of the blood. Thes disorders are discrete disease entities resulting from distinct and separat causes, each form exhibiting its own peculiar characteristic symptoms. On group of anemias is caused, under certain circumstances, by iron deficienc Attempts to treat other types of anemia with iron are necessarily futile Until the anemias were classified and their various causes understood, th failure of iron therapy in anemias not arising out of iron deficiency led t considerable controversy regarding the significance of iron deficiency.

Normal Physiological Role of Iron:

Iron, in combination with certain pigment materials, the porphy rins, forms a series of compounds known as the heme pigments. These pigments, of which hemoglobin is perhaps the best known and most widely investigated, are vitally concerned with a number of funda mental living processes. Iron is required not only for hemoglobin formation, but also for the construction of myoglobin (muscle hemo globin) and of such respiratory and enzymic pigments as cytochrome catalase, Warburg's respiratory pigment, and peroxidase (7).

Hemoglobin: The red blood cell pigment, hemoglobin, is a com pound of a colorless protein, *globin,* and an iron porphyrin pigment (7). The chief function of hemoglobin is the transportation of oxygen from the lungs to various tissues of the body and the removal of car bon dioxide from the tissues to the lungs where it is eliminated via respiration. Many factors are involved in the formation of hemo globin and in the regeneration of new hemoglobin following blood loss or in certain types of anemia. Iron is important among these factors, although it constitutes but a small fraction of the hemoglobin molecule.

Iron in the Body: The iron content of the human body has been estimated by Sherman (8) to be about 3.0 grams, and by others (2) as about 4.3 grams. Most of the body iron (generally estimated at about 2.65 grams) is present in the blood as the heme (or hematin) portion of the hemoglobin molecule (2). The remainder of the body iron is divided between "latent" iron in storage depots for emergency

use in building new hemoglobin, and small amounts of iron as myoglobin in the muscles (muscle hemoglobin iron) and as an essential constituent of all other body tissues (parenchyma iron). The latter two (muscle hemoglobin iron and parenchyma iron) are inviolate stores of iron which are not drawn upon no matter how great the emergency due to anemia (9).

Iron Metabolism:

The mechanism of iron metabolism is exceedingly complicated. Hahn predicts many years will pass before a complete knowledge is forthcoming concerning the transformations which iron undergoes in the body during its absorption, storage, fabrication into its several working forms, liberation, conservation and excretion (1).

The investigation of iron metabolism has centered chiefly around three phases: absorption, storage and utilization. The following is a highly abbreviated summary of present knowledge in this field.

Absorption: The absorption of iron from the digestive tract depends chiefly upon two factors: (1) the form in which it is ingested and, (2) its "availability," or the completeness with which it can be separated from chemical and physical combinations in foods for utilization by the body. It is generally believed that to be absorbed iron must be soluble, ionizable and ultrafiltrable (10). The forms which meet these conditions are reduced iron (finely powdered, metallic iron), acid-soluble iron salts, and ferric hydroxide (or its absorption complexes) which latter are slowly ionized in acid solution. The iron in foods is chiefly in the ferric form, but is readily reduced in the stomach to the ferrous form in which condition it is readily utilized. It is recognized, however, that a number of factors may contribute to difficulty in absorbing iron regardless of the form in which it is ingested. Such factors include interference with the secretion of hydrochloric acid in the stomach, the body needs for iron as influenced by the state of iron reserves, and the formation of insoluble iron compounds in the intestine.

Storage: Iron is stored in almost all organs of the body. The liver is believed to be the chief storage depot. The iron in hemoglobin constitutes the largest fraction of body iron. In addition this element is stored in various organs as "reserve" iron for use in hemoglobin production when needed and as unavailable myoglobin and parenchyma iron. Reserve iron is stored chiefly in the liver, spleen, kidney and probably red bone marrow. Unavailable parenchyma iron (as esti-

mated in blood-free organs) is highest in the red bone marrow, wit correspondingly lesser stores in the spleen, liver, kidney and pancrea

Utilization: (*Influence of Copper*) The utilization of iron fo hemoglobin formation depends upon a large number of factors, pe haps the most important of which is the presence of minute traces o copper. The role of copper, according to Elvehjem (11), is not co cerned with the actual absorption and assimilation of iron, but is in volved in the transformation of assimilated iron into hemoglobi The function of copper in this respect is apparently catalytic since i does not enter into the end products of the reactions involved, no does it constitute any portion of the hemoglobin molecule. Coppe salts have been shown to be of value in experimental anemia in ani mals; their usefulness in human anemia has not been incontrovertibl indicated.

(*Influence of Calcium*) Calcium has been shown to be anothe factor involved in the efficient utilization of iron. On the basis o several short term human metabolism experiments conducted mor than 30 years ago, Sherman (12) suggested a "sparing" action of cal cium on iron. About eight years ago, more definite evidence was give by Orten, Smith and Mendel (13) who found that the addition o small amounts of calcium materially improved the blood picture o rats made anemic by mineral deprivation. Other factors have bee shown to influence the utilization of iron for the production of hemo globin. These include the general state of health, and the dietar adequacy of proteins, vitamins and minerals (14, 15, 16).

Excretion: Iron is not excreted by either the kidneys or the in testinal tract to any appreciable extent. It has been called a "one-wa substance", that is, it may be absorbed, but it is not excreted. Dietar iron which remains unabsorbed will pass through the digestive trac and be eliminated in the stools – but it is not, in the ordinary sense, excreted (17). A negative iron balance – that is, an excess of iron contained in the urine and feces over the amount of iron ingested – is believed to be rare under ordinary conditions. A positive balance (storage), on the other hand, is observed in growing children and pregnant women receiving optimum amounts of the mineral.

Iron Deficiency Anemias:

The role of iron in the development and treatment of the hypo chromic microcytic* or iron-deficiency anemias is exceedingly com-

*Hypochromic (literally, "low color") microcytic ("small cell") anemias are characterized by a reduction in hemoglobin content and size of the red blood cells, thereby importing a paler appearance to the blood. They are distinguished from anemias in which the hemoglobin content of the individual erythrocyte (red blood cell) may be normal, but the total number of cells is reduced.

plex and subject to considerable controversy. The situation has been described succinctly by Whipple and Robscheit-Robbins (14):

"It would seem that the reaction of iron in anemia should be delightfully simple and direct. There is a lack of iron and when absorbed or injected it should go directly into upbuilding of the large hemoglobin molecule which thereupon is incorporated into the red cell. The reasons why the reaction is so often confusing, unexpected and difficult of explanation are subject to debate, but one may at least suspect that iron is concerned . . . . . .

"A monument erected to commemorate developments in iron metabolism would be, indeed, a Tower of Babel. Voices would be raised to convince us that metallic, reduced or inorganic iron is utilized differently and less effectively than organic or food iron. Again claims are put forward that ferrous iron is utilized to greater advantage than ferric iron. Some investigators believe that copper is necessary for the utilization of iron. Others believe that much more iron is taken into the body from the intestine than is utilized and that much of this is excreted as a surplus *via* the large bowel. Iron balance experiments do not tell us whether some of the iron is taken into the body and then eliminated in the feces, as it all may go through the intestine and escape in the feces.

"Some of the confusion in this voluminous literature is due to an attempt to apply findings in one type of anemia to a totally different type of anemia."

Iron deficiency anemia occurs most often when requirements are greatest and drains upon the stores of iron heaviest. Low dietary intakes of iron are regarded as secondary causes of anemia, and are believed to result in anemia only when occurring in conjunction with heightened body requirements. Factors which interfere with absorption from the gastro-intestinal tract are also contributory.

Conditions Increasing Iron Requirements: The need for iron varies greatly at different ages and under different conditions. The major importance of a diet containing liberal amounts of iron is not so much to directly prevent the development of anemia, as it is to contribute to or maintain the body reserves of iron for use in emergencies. Thus, if the "latent" stores of iron are low due to inadequate dietary intake, any condition calling upon the reserves of iron for hemoglobin formation will be prone to precipitate a hypochromic anemia. For this reason, hypochromic iron deficiency anemias are most likely to appear:

(1) in infancy and childhood
(2) in young girls during puberty ("chlorosis")
(3) in adult women due to excessive blood losses of menorrhagia and repeated pregnancies ("idiopathic" hypochromic anemia)
(4) in adult women during pregnancy
(5) in males and females due to severe blood loss

(1) *Hypochromic anemia of infancy* usually occurs after th fourth month of infancy. Prior to that time the iron needs are met b the reserve of iron in the liver with which the child has been supplie by the mother. The increasing demands of growth (an expandin blood volume) and the relatively low dietary intake of iron com bine to deplete the iron reserves with the consequent developmen of anemia. Infectious diseases or gastro-intestinal abnormalities such as diarrhea or achlorhydria may also be contributing factors. Pre mature infants in whom iron stores may be incomplete or twin who must share their iron stores are particularly susceptible. Iron deficiency anemias in infants respond readily to iron therapy. Such anemias can be prevented by providing the mother during pregnancy with a diet sufficiently liberal in iron to endow the infant with an adequate reserve during the early months when the iron intake is low

(2) *Chlorosis* is an iron deficiency anemia occurring in adolescent girls due to the combined demands of growth and menstruation. If no anemia was present during infancy, if the iron reserves are large during puberty and if the dietary intake is rich in iron, the excessive demands for iron can be met without the development of anemia.

(3) *"Idiopathic" hypochromic anemia* is a vaguely defined type of iron deficiency anemia occurring in middle-aged women. It is fre quently associated with achlorhydria. When coupled with inadequate dietary supplies of iron, primary factors in the development of this anemia are blood loss from various causes, particularly menorrhagia and depletion of iron stores by repeated pregnancies.

(4) *Pregnancy* results in a moderate "physiological anemia" due to an increase in the total plasma volume. In addition to this, an iron deficiency anemia may develop because of the demands of the fetus. Post-partum hemorrhage and iron loss in lactation are additional contributory factors. An iron-rich diet is essential for the pregnant woman, not only to prevent anemia in herself, but to guard the in fant against anemia by providing it with a liberal reserve of iron.

(5) *Severe or chronic blood loss* may result in iron deficiency anemia at any age. Inasmuch as the great majority of body iron is present in the blood, blood loss is synonymous with iron loss. Prin cipal sources of blood loss are bleeding peptic ulcer, gastro-intestinal bleeding from other causes, hemorrhoids, menorrhagia, normal and abnormal bleeding associated with pregnancy. Persistent bleeding of these types gradually depletes the iron stores and, unless these are constantly replenished by an iron-rich diet, anemia will result. Acute

blood loss, as in wounds or donation of blood, is soon compensated by drawing upon the iron reserves. Blood donors, particularly, require high iron diets to build and replenish their iron reserves.

The Diet in Nutritional Anemia: The diet in anemia should provide (1) an abundance of iron-rich, as well as blood-building* foods, and (2) adequate amounts of all nutritive essentials, particularly the vitamins, minerals and protein. Patients with iron deficiency frequently suffer from other deficiencies as well, particularly protein. According to McLester (16):

> "The urgency of the need for protein is seen in the fact that 75% of the nitrogen of the blood is incorporated in hemoglobin and that the plasma protein value is often low. The latter can be corrected only by giving liberal amounts of protein. The diet should always provide milk, at least two glasses daily, skimmed if necessary; its poor iron content is compensated for by its richness in calcium, vitamins and good proteins."

In iron deficiency anemia, administration of liberal doses of medicinal iron in various forms is an important adjunct to proper diet.

Normal Physiological Requirements for Iron:

As noted in the preceding section, the normal physiological iron requirements are, in the male, for the needs of growth and, in the female, for the needs of growth, menstruation, pregnancy and lactation. In addition, the need for tissue iron and for iron reserves must be considered in computing the total requirement of iron. Further, since a great deal of the iron in foods is not available for utilization by the body, this must be taken into account when estimating the optimum dietary intake of iron. The National Research Council has recommended the following daily intakes of iron for various groups:

Recommended Daily Allowance for Iron

(Committee on Food and Nutrition, National Research Council)

	Iron, Mg.
Children under 1 year	6
Children 1-3 years	7
Children 4-6 years	8
Children 7-9 years	10
Children 10-12 years	12
Girls 13-15 years	15
Girls 16-20 years	15
Boys 13-15 years	15
Boys 16-20 years	15
Women, nonpregnant	12
Women, pregnant	15
Men	12

*Whipple and co-workers have found certain foods regardless of iron content effective in the regeneration of hemoglobin (liver, kidney, etc). They isolated from liver a fraction, distinct from the anti-pernicious anemia principle, which was effective in treating anemic dogs (18). This fraction has been found of value as a supplement to iron in the clinical treatment of human iron deficiency anemia (19).

These allowances have been suggested on the basis of iron balance studies conducted by various research groups. Because it is almost impossible, in the case of iron, to obtain precise data from balance studies, a liberal margin of safety is added to the averages reported.

Iron Balance Studies: Iron balance studies on male adults were reported as early as 1897. Results of the early studies indicated a probable minimum requirement of 10 milligrams of iron per day (20). On this basis Sherman proposed a standard allowance of 15 milligrams a day for male adults, an amount which incorporated a fifty per cent factor of safety over the minimum of 10 milligrams.

In the case of women, iron balance studies have been complicated by the factors of menstruation and pregnancy. Leverton and Roberts (21) studied the iron metabolism of four normal young women during consecutive menstrual cycles. They found that on an intake of at least 0.23 mg. of iron per kilogram of body weight (or about 10 mg. per day for a 50 kg. woman), no cases of negative balance occurred during menstruation despite small losses of iron occurring at that time. The iron balances of women at different stages of pregnancy have been studied by Coons (22) who reported good iron retentions on intakes ranging from 9.7 to 19.5 mg. of iron per day.

A number of investigators have reported results of iron balance studies on children (23, 24, 25, 26). In general it has been found that under ordinary conditions of feeding, iron balances of children are slightly positive. This is because of the heightened requirements imposed by rapid growth. For adequate retention of iron, it has been concluded that the diet should provide about 0.6 mg. of iron per kilogram of body weight for children within the pre-school age group or early school years. Thus, a six-year old child weighing 20 kg. (about 44 lbs.) should have an intake of about 12 mg. of iron, or the same amount as for an adult.

Dietary Sources of Iron:

Because of variations in the availability of iron from various food sources, a table of the iron content of foodstuffs is not of particular significance in evaluating foods as dietary contributors of iron. Thus, although analyses may indicate a very high iron content for a certain food, this iron may not be well utilized by the body. From a practical point of view, therefore, the food is a poor source of iron. Conversely, a food of low iron content, which contains the iron in readily utilizable form, may well rank as a superior source of dietary iron.

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Experience has shown that a well chosen diet, adequate in calories, and containing meat, eggs, colored vegetables and whole grain flour or cereals, will satisfactorily meet iron requirements. Among the rich sources of available dietary iron are liver, kidney, beef, egg yolk, oatmeal, molasses, prunes, apricots, raisins, and peaches. Milk contains very little iron, but whatever iron is present is in a form which is readily absorbed and utilized by the body. Because of its abundant supply of calcium, vitamins and superior protein, – factors which markedly influence iron utilization – milk has an important place in any diet designed to improve the iron supply.

Iron Fortification of Foods: It is generally accepted that a varied, well-chosen diet will be adequate, with respect to iron, for all healthy male adults. The possibility exists, however, that under actual conditions that diet may contain excessive amounts of vitamin- and mineral-poor foods such as sugar, highly sweetened manufactured products, white flour bakery goods and refined cereals. This type of diet may be especially low in iron and inadequate in particular for persons in substandard physical condition, and for women and growing children. In addition, much of the iron of the diet may not be available for efficient utilization by the body. For these reasons, it has been deemed advisable to fortify certain staple foods, notably white flour and refined cereals, with iron salts and other nutrients. In general, the aim of food fortification is the restoration of the nutritive values natural to the unrefined food, or the supplementation of natural food carriers.

The fortification of flour, farina, milk, milk flavorings, modified milk products and other foods with iron involves various technical problems: the choice of an appropriate iron salt for simplicity of incorporation; effect on palatability; nutritional availability of the iron in the food; and the possible detrimental effect on the keeping qualities of the food to be enriched. In many cases, these problems are being successfully met. Enriched flour, farina and bakery goods and fortified milk and other foods, to which iron is added are some successful ways for preventing iron inadequacies in the national diet.

REFERENCES CITED

1. HAHN, P. F. The metabolism of iron. Medicine *16*, 249 (1937).

2. HEATH, C. W. and A. J. PATEK, JR. The anemia of iron deficiency. Medicine *16*, 267 (1937).

3. SUYDENHAM quoted by FOWLER, W. M. Chlorosis—an obituary. Ann. Med. History *8*, 168 (1936).

4. WILLIS quoted by FOWLER, W. M. Chlorosis—an obituary. Ann. Med. History *8*, 168 (1936).

5. MENGHINI. De ferrarum particularum sede in sanguine, 1746, quoted by HALFER, G. Le fer dans le sang chez les enfantes malades. Arch. d. Med. d. Enfants *33*, 659 (1930).

6. BLAUD, P. Sur les maladies chlorotiques, et sur un mode de traitement spécifique dans ces affections. Rev. med. franc. et etrang. *1*, 337 (1832).

7. ANSON, M. L. and A. E. MIRSKY. Hemoglobin, the heme pigments and cellular respiration. Physiol. Rev. *10*, 506 (1930).

8. SHERMAN, H. C. *Chemistry of Food and Nutrition*, 6th Ed. The Macmillan Company, New York (1941).

9. HAHN, P. F. and G. H. WHIPPLE. II. Iron metabolism. Its absorption, storage and utilization in experimental anemia. Am. J. Med. Sci. *191*, 24 (1936).

10. DAVIDSON, L. S. P. and I. LEITCH. The nutritional anaemias of man and animals. Nutr. Abst. and Rev. *3*, 901 (1934).

11. ELVEHJEM, C. A. The biological significance of copper and its relation to iron metabolism. Physiol. Rev. *15*, 471 (1935).

12. SHERMAN, H. C. U. S. Dept. Agr. Bull. 185 (1907).

13. ORTEN, J. M., A. H. SMITH and L. B. MENDEL. Relation of calcium and of iron to erythrocyte and hemoglobin content of blood of rats consuming mineral deficient ration. J. Nutr. *12*, 373 (1936).

14. WHIPPLE, G. H. and F. S. ROBSCHEIT-ROBBINS. Iron and its utilization in experimental anemia. Am. J. Med. Sci. *191*, 11 (1936).

15. LEVERTON, R. and A. G. MARSH. Iron metabolism and requirement of young women. J. Nutr. *23*, 229 (1942).

16. MCLESTER, J. S. *Nutrition and Diet in Health and Disease*. 4th Ed. W. B. Saunders Company, Philadelphia and London (1943).

17. HEATH, C. W. Iron in nutrition. J. Am. Med. Assoc. *120*, 366 (1942).

18. WHIPPLE, G. H., F. S. ROBSCHEIT-ROBBINS and G. B. WALDEN. Blood regeneration in severe anemia: liver fraction potent in anemia due to hemorrhage. Am. J. Med. Sci. *179*, 628 (1930).

19. BARKER, W. H. and D. K. MILLER. Clinical observations on the Whipple liver fraction. Am. J. Med. Sci. *195*, 287 (1938).

20. BING, F. C. Iron, in *Mineral Metabolism*, by A. T. SHOHL. Rheinhold Publishing Corp., New York (1939).

21. LEVERTON, R. M. and L. J. ROBERTS. The iron metabolism of normal young women during consecutive menstrual cycles. J. Nutr. *13*, 65 (1937).

22. COONS, C. M. Iron retention by women during pregnancy. J. Biol. Chem. *97*, 215 (1932).

23. ASCHAM, L. A study of iron metabolism with pre-school children. J. Nutr. *10*, 337 (1937).

24. DANIELS, A. L. and O. E. WRIGHT. Iron and copper retentions in young children. *8*, 125 (1934).

25. LEICHSENRING, J. M. and J. H. FLOR. The iron requirement of the pre-school child. J. Nutr. *5*, 141 (1932).

26. ROSE, M. S., E. M. VAHLTEICH, E. ROBB and E. M. BLOOMFIELD. Iron requirement in early childhood. J. Nutr. *3*, 229 (1930).

NEWS DIGEST

AMINO ACID REQUIREMENTS—Latest findings reveal that eight of the ten amino acids essential for animals, are also indispensable for human beings.* These are valine, leucine, isoleucine, threonine, methionine, phenylalanine, tryptophane and lysine. Some doubt exists as to the probable significance of histidine and arginine which, while indispensable for animals, seem to be important for man only under certain circumstances. Experiments are now under way to determine minimum daily requirements of the eight amino acids for the average male adult.

Final determination of the exact quantitative and qualitative amino acid requirements of human beings will be of practical value in calculating protein requirements more accurately, and in evaluating more precisely the biological significance of specific protein foods. Knowledge of exact amino acid requirements will also be of considerable importance in problems associated with the use of amino acid mixtures in intravenous alimentation. *Adapted from an address given by W. C. Rose, 3rd Mary Schwartz Rose Memorial Lecture, N. Y. Academy of Medicine,* Feb. 16, 1944.

PROTEIN NUTRITION—Investigations during the past few years have brought to light the interesting observation that the liver serves as an indicator of the adequacy of dietary protein intake. When rats are fed a diet low in protein, but adequate in all other respects, the liver loses weight, its protein level is reduced, the water and carbohydrate contents are greater and there is a tendency toward the deposition of fat. With experimental animals in such a condition, it becomes possible to test the dietary adequacies of specific proteins. The addition of a biologically inadequate protein to the diet of such animals produces no improvement in the liver condition. The addition of an adequate protein results in a rapid increase in the size of the liver, in the protein content, and in the restoration of the normal chemical composition with respect to the other constituents. The return to normality is usually complete in about two weeks. Analyses of the livers of many animals, treated identically in this manner, have yielded remarkably consistent results as to the adequacy or inadequacy of the protein tested. *Proc. Inst. Med. of Chicago, 15,* 42 (1944).

EMERGENCY DIETS—Emergency rations have been planned for use in liberated countries where the recipients may possibly have to subsist exclusively on such diets for several weeks. Dry skim milk is used to supplement the proteins of soy products and of wheat, as well as to provide an adequate source of calcium and of the B vitamins, especially riboflavin. Vitamin C may be supplied by citrus concentrates, lemon powder with added ascorbic acid or sprouted peas and beans. A fat, more highly fortified than margarine, supplies vitamins A and D. Other needed nutrients are to be supplied in amounts as close as possible to National Research Council standards. The caloric provision is about 2000 calories per person per day in an amount of food weighing slightly over one pound. There are four such emergency rations:

*See *Borden's Review of Nutrition Research,* Vol. IV, No. 1, and Vol. IV, No. 4 for previous information on these experiments.

a. 2 to 4 ozs.: dried precooked soup containing brewer's yeast, dried skim milk, dried peas, and seasoning.
b. 3 to 4 ozs.: precooked fortified cereal
c. 1 to 5 ozs.: biscuit of the Army K-ration type
d. peanut butter-soy spread for use on biscuit; fat for use in soup or as spread; and a source of vitamin C

The rations contain no meat, fish or poultry, very little or no dried egg, and no vegetables or fruit except the dried legumes and citrus concentrates. *J. Amer. Diet. Assoc. 19,* 267 (1943).

THIAMIN LOSS IN TOASTING—Toasting bread results in loss of some of the vitamin B_1 content. Tests were conducted with breads made fr whole wheat flour, enriched white fl and unenriched white flour to de mine the extent of these losses. T bread slices were toasted for 30, 40, 60 and 70 seconds. The thiamin c tent decreased with increased times toasting. In micrograms per gram bread, on a 38% moisture basis, thiamin values for untoasted and seconds toasted slices, respectively, we

whole wheat bread.....3.36 and 2
enriched white bread.....2.76 and 2
unenriched white bread.....0.86 and 0

In the order given the percenta losses were 21%, 17% and 31%. relation was apparent between loss moisture and loss of vitamin B_1. *Cer Chem. 20,* 352 (1943).